

Validation of OMI and GOME-2A\B tropospheric NO₂, SO₂ and HCHO products using MAX-DOAS observations in Wuxi, China, Part2: effects of coincidence criteria, clouds and a-priori profiles



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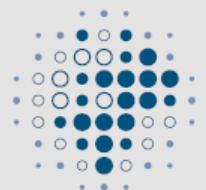
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Overview:

- Where is Wuxi city? And motivation
- Involved satellite products
- Effects of coincidence criteria
- Comparisons of daily data and cloud effect
- Effects of normalized a-priori profile (shape factor) of trace gases from CTM on satellite Trop. VCD products
- Conclusion



Motivation

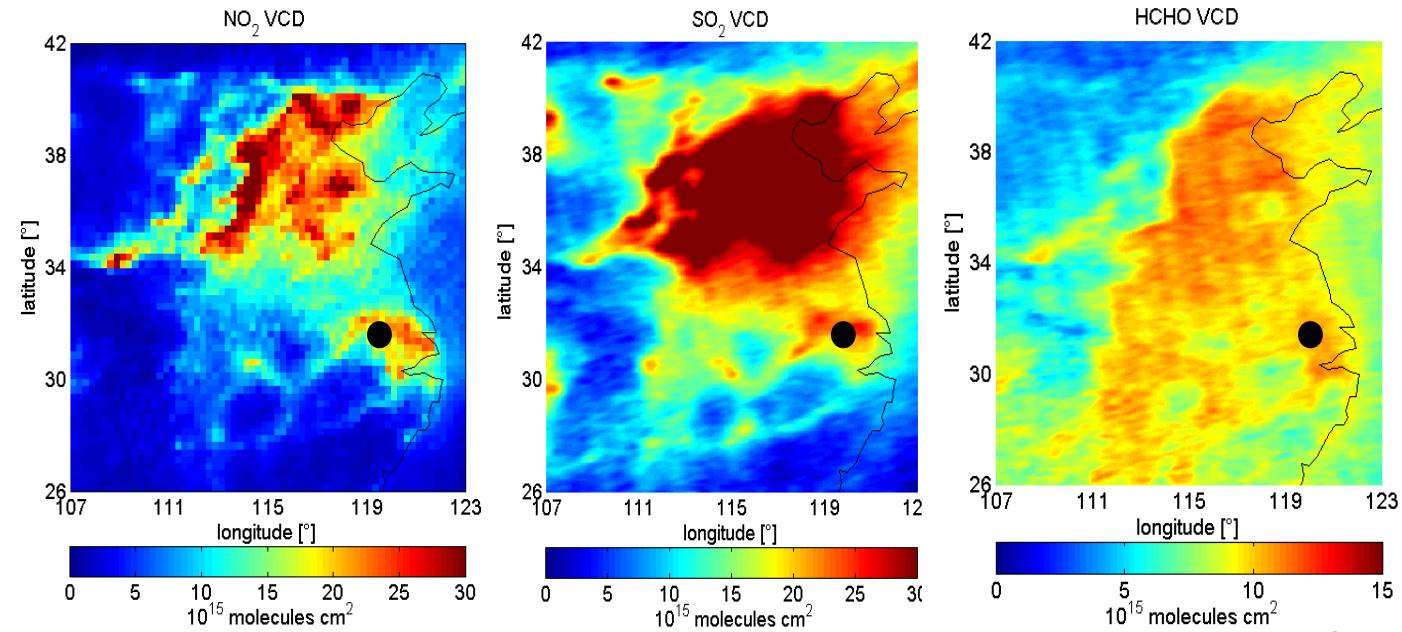
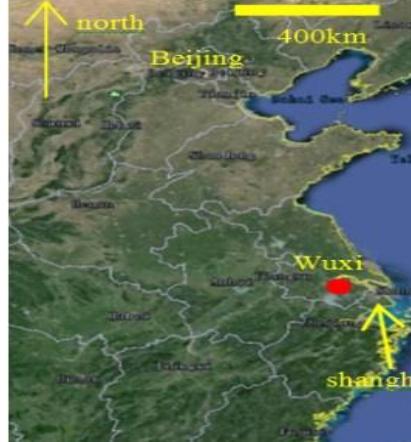
Part1 work: aerosol effects on satellite retrievals (OMI science meeting 2015) using MAX-DOAS observations in Wuxi

Validation studies focus on

- coincidence criteria:

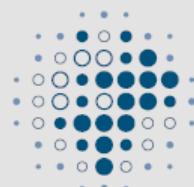
MAX-DOAS: coincidence time period; Satellite: coincidence area

- Cloud effect: separate effects on MAX-DOAS and satellite
- Error of shape factors from CTM and its effect on satellite Trop. VCD products
- Comparisons of daily (2h around overpass time) averaged data



- 3 -

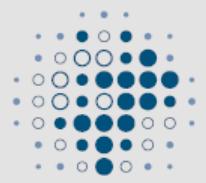
Wuxi in the heavy industrialized area: Yangtze River delta (YRD). YRD is the largest metropolitan area in Asia with the population of 150 millions.



Satellite data (2011-2014)

Instr.	species	product	reference	A-priori profile (SF)
OMI	NO ₂	DOMINO	Boersma et al., 2007 and 2011	TM4 CTM
	SO ₂	BIRA-IASB	Theys et al., 2015	IMAGESv2
		NASA OMSO2 PBL	Li et al., 2013	fixed
	HCHO	BIRA-IASB	De Smedt et al., 2015	IMAGESv2
GOME-2 A/B	NO ₂	TM4NO2A v2.3	Boersma et al., 2004	
	SO ₂	BIRA-IASB	Theys et al., 2015	
		O3M-SAF	Rix et al., 2012 and Hassinen et al., 2016	
	HCHO	BIRA-IASB	De Smedt et al., 2015	





MAX-DOAS measurements in Wuxi station

MINI MAX-DOAS from 2011 to 2014:

- Spectral range: 290 – 425 nm (NO_2 , SO_2 , HCHO and O_4).
- Elevation angle: 5°, 10°, 20°, 30° and 90°
- Azimuth angle: Exact north

SCD retrieval:

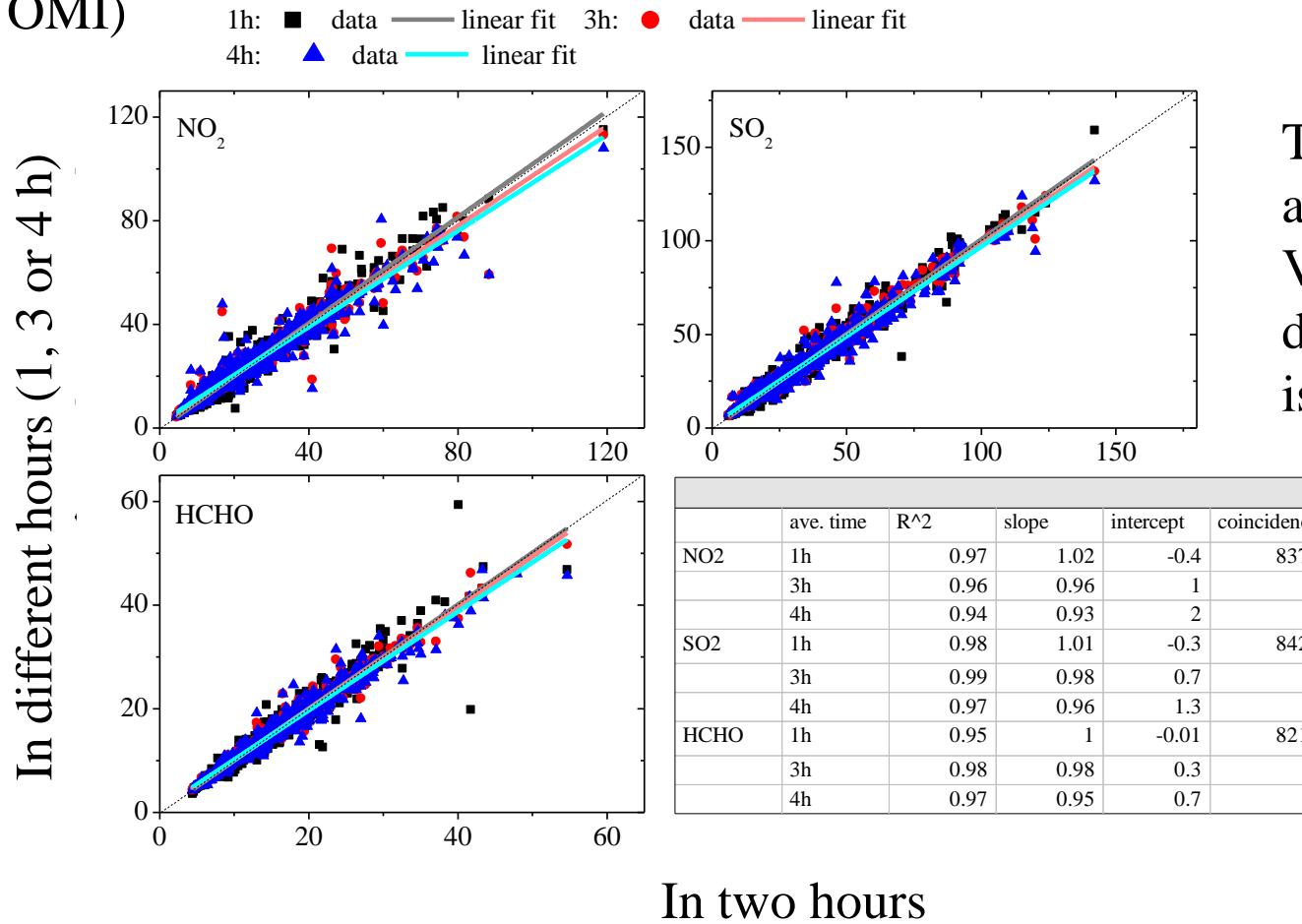
- O_4 and NO_2 , 350 nm – 391 nm; SO_2 , 307.8 – 330; HCHO, 324.6 nm – 359 nm
- Filters: shift < 1 pixel, offset correction < 1%, RMS < 0.01, SZA < 75°

Trop. VCD and profile:

- **Nonlinear optimal estimation method** to retrieve profiles of aerosol extinction and trace gas VMR, then integrate profiles to acquire VCD.
- The MAX-DOAS results are discussed and **reported in Wang Yang, et al., ACPD, 2016**

Effects of coincidence criteria

1. Temporal coincidence of MAX-DOAS data: average around overpass time (e.g. OMI)

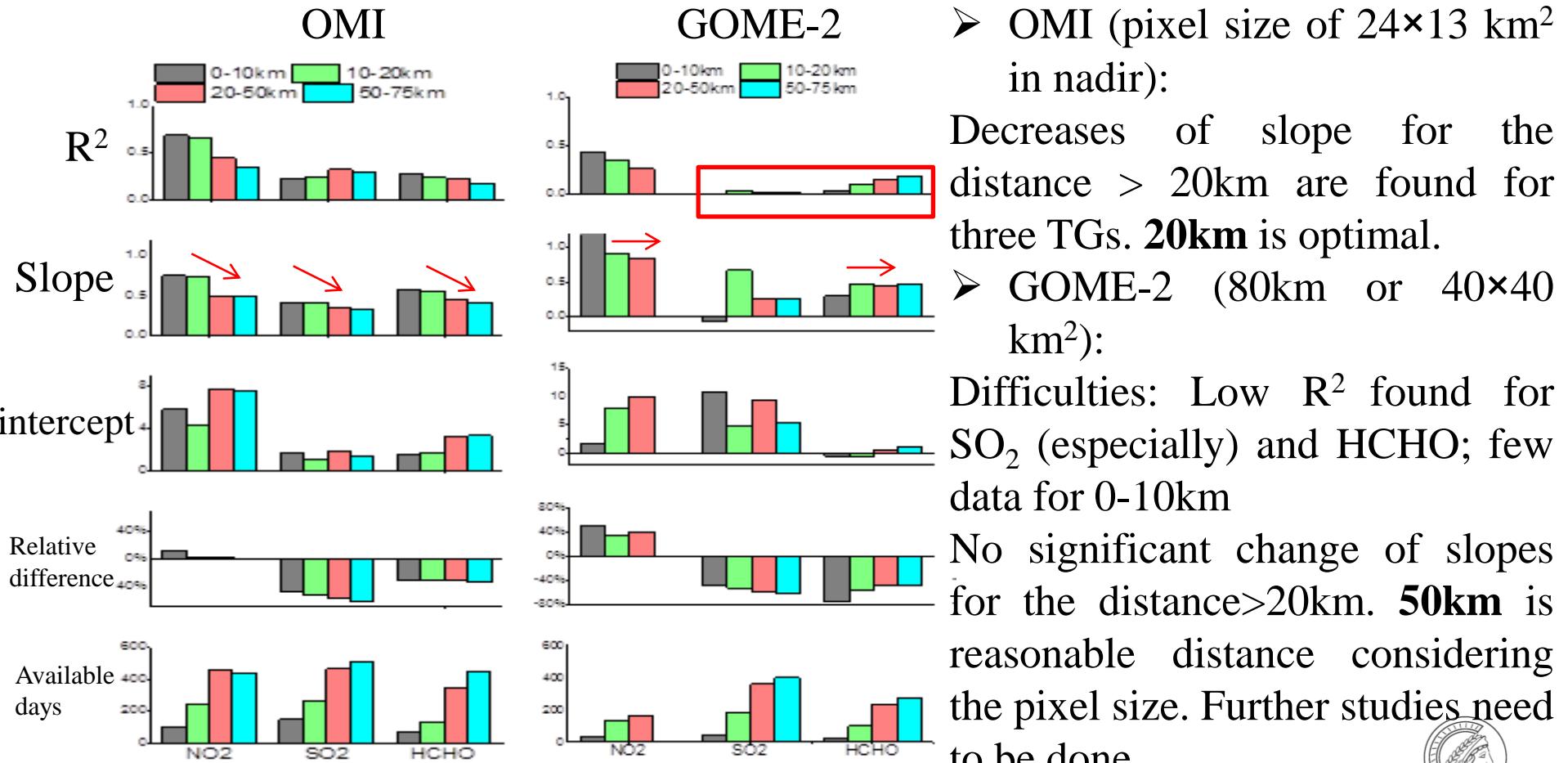


The systematic bias of averaged MAX-DOAS VCDs between in different time periods is negligible.

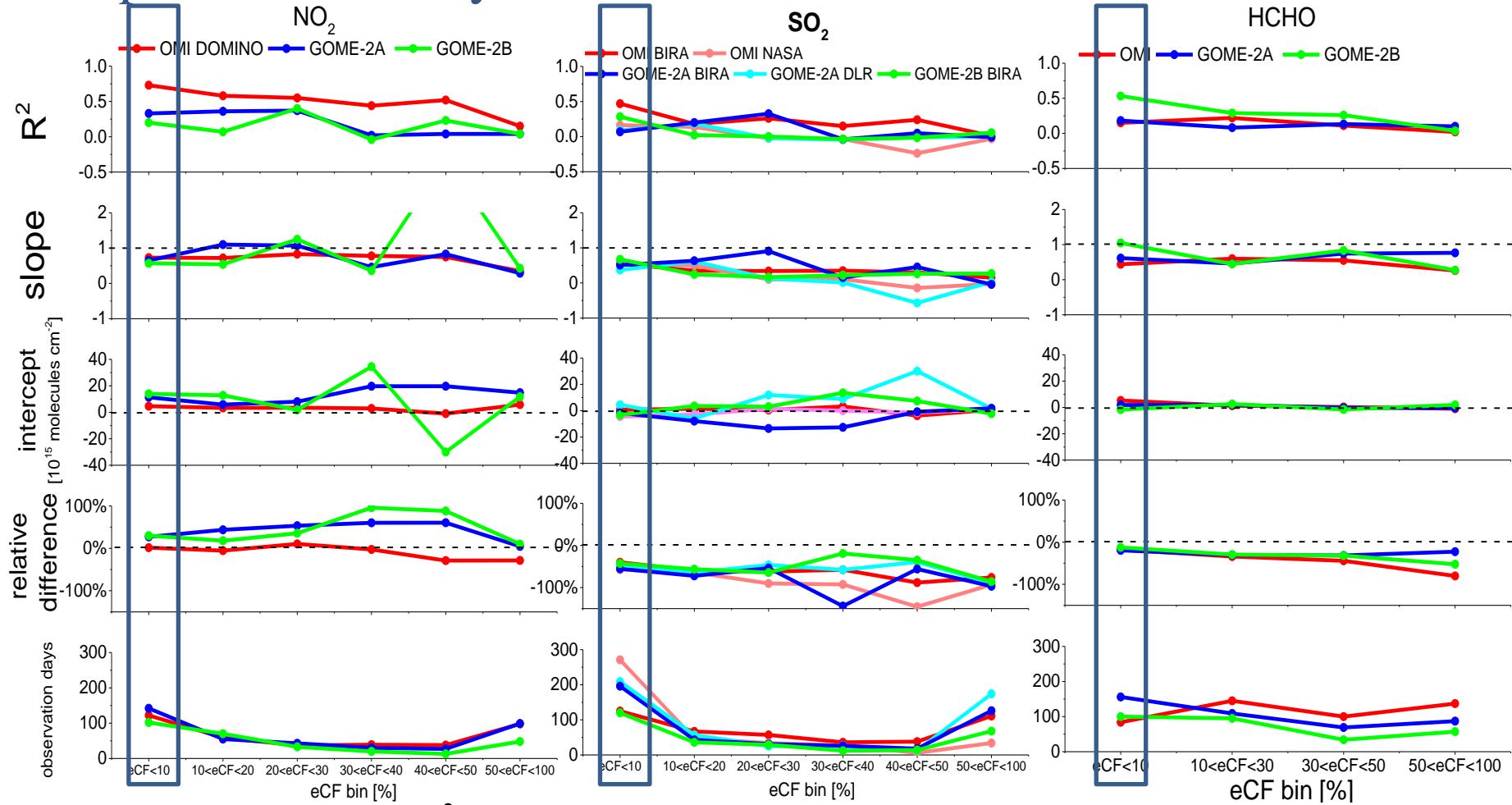
Effects of coincidence criteria

2. Spatial coincidence of satellite data:

Parameters of statistic comparisons with MAX-DOAS for different coincident areas



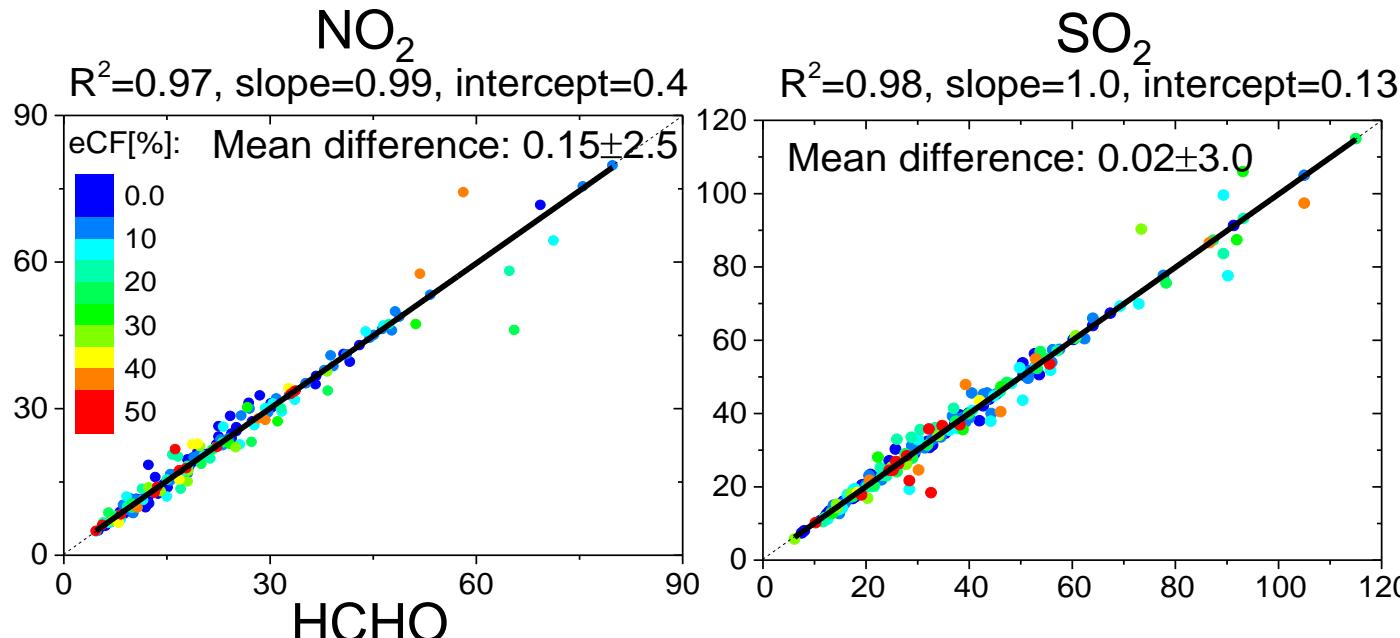
Comparisons of daily data and cloud effect



- NO₂: OMI best agreement, R² of 0.73 and systematic bias of 1%; GOME-2A better than B (swath of GOME-2A change from 1920km to 960 km since 15 July 2013); both are lower by ~30%.
 - SO₂: OMI BIRA best agreement, R² of 0.47, all products are lower by ~40% to 57%.
 - HCHO: GOME-2B best agreement, R² of 0.53, all products are lower by ~10% to 20%.
 - Cloud effect: R² decrease and average bias increase along increase eCFs.
- eCF thresholds: for OMI NO₂, increase of relative difference for eCF>40%;
for GOME-2A/B NO₂, decrease of R² for eCF>30% .

Cloud effect on MAX-DOAS results

Aver. MAX-DOAS VCD under all condition



Aver. MAX-DOAS VCD under clear sky condition [10^{15} molecules cm^{-2}]

Sky conditions identified by MAX-DOAS
and for each measurement, Wang Y. et al.,
AMT, 2015

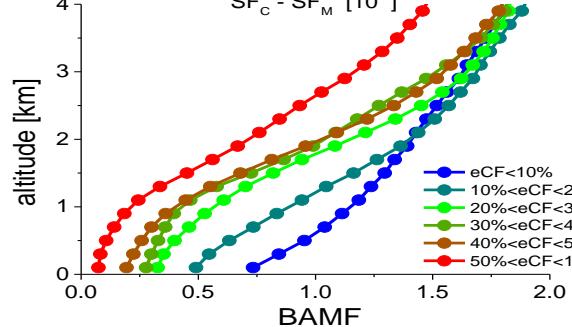
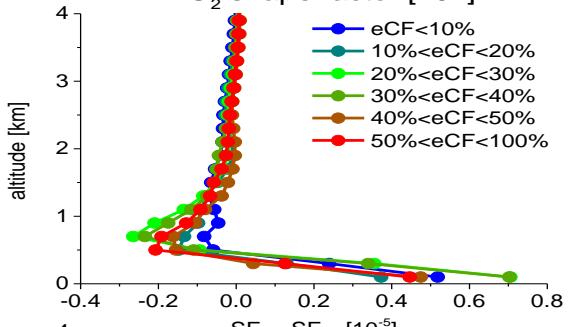
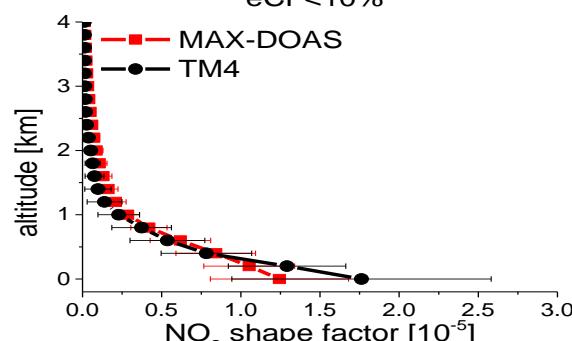
**No systematic bias of MAX-DOAS
VCD due to cloud effect (under broken
clouds)**

In 2 hours
around
13:30 (OMI
overpass
time)

Effects of a-priori shape factor of trace gases

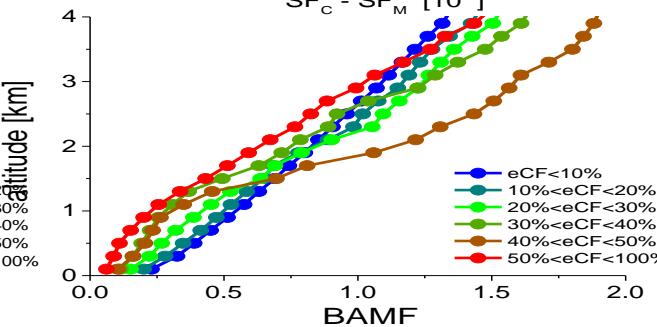
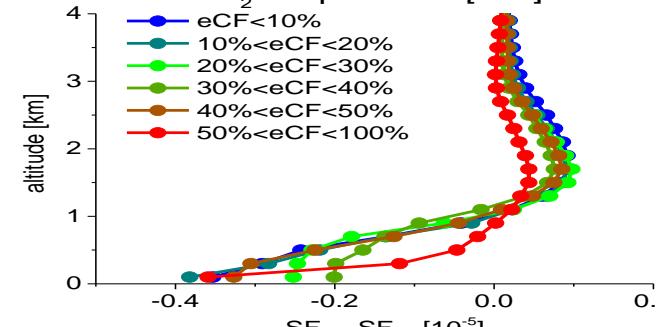
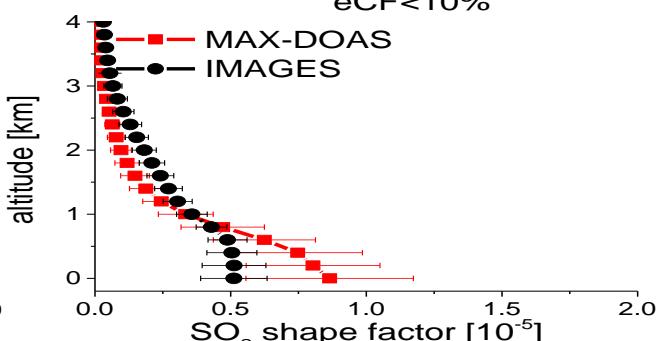
NO₂

eCF<10%



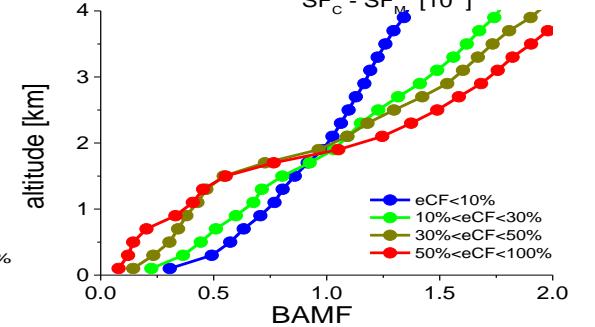
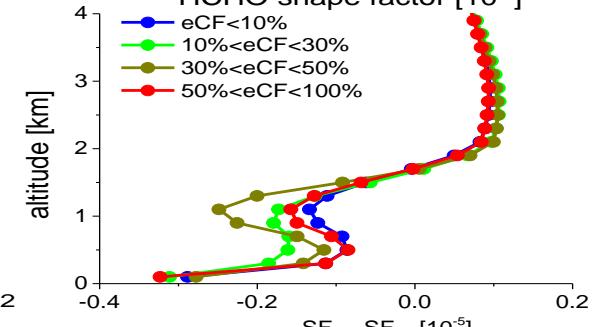
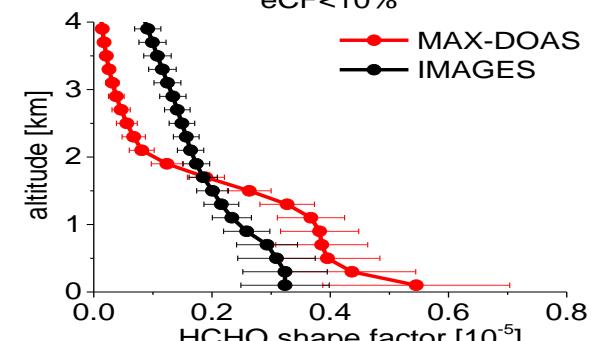
SO₂

eCF<10%



HCHO

eCF<10%



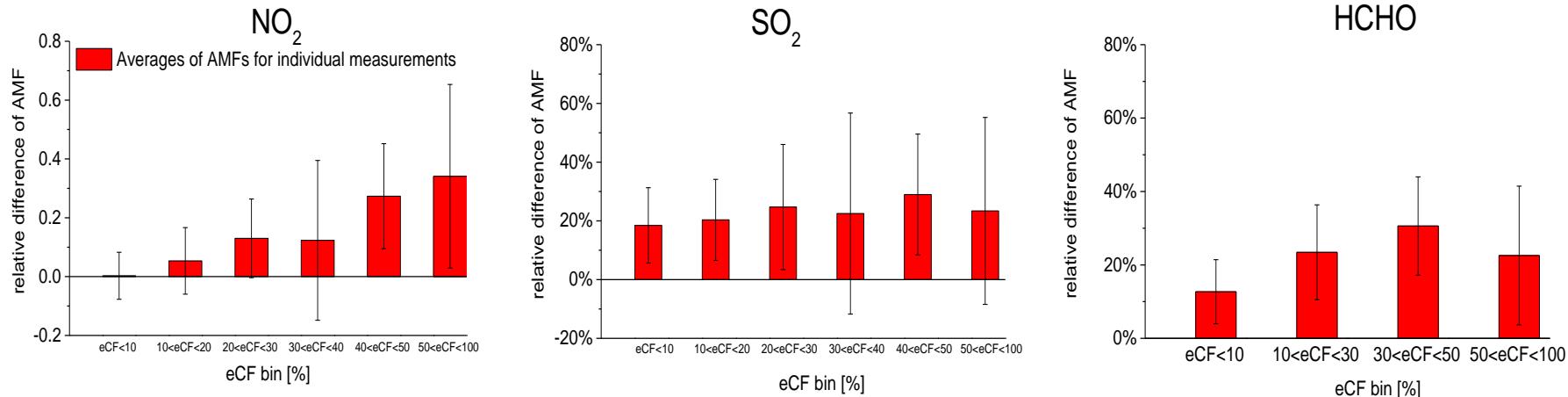
SF in clear sky: for NO₂ SF(MAX-DOAS) < and > SF (TM4) near surface and above 0.5km, for SO₂ and HCHO SF(MAX-DOAS) > and < SF(IMAGES) near surface and at high altitudes.

SF for all eCF: similar as in clear sky

Box AMF: depends on eCF for NO₂> SO₂ and HCHO

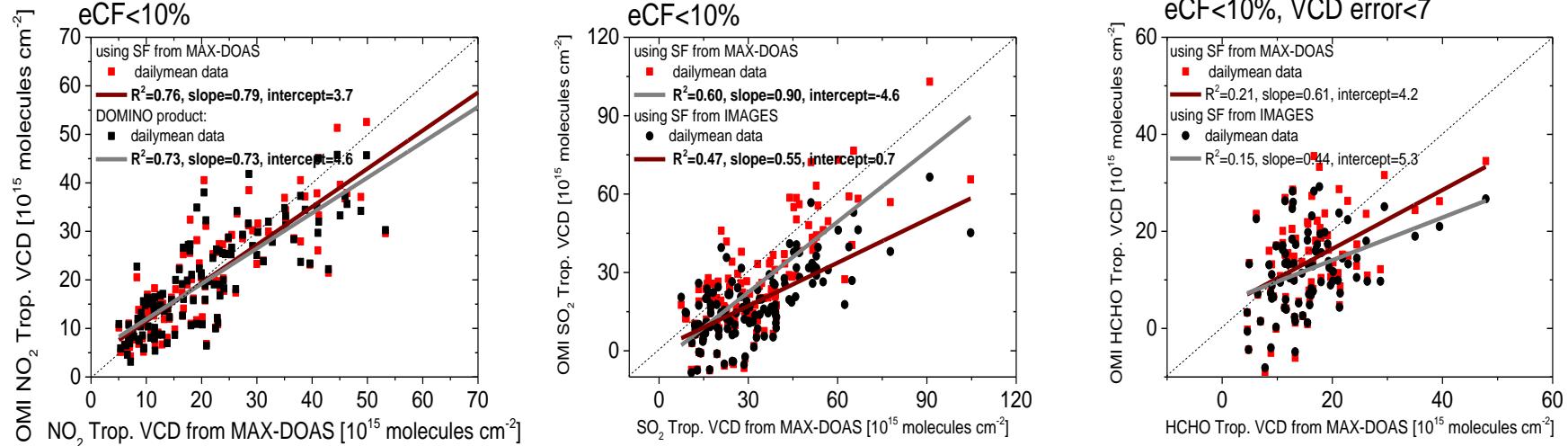
Effects of a-priori shape factor of trace gases

$\text{AMF}(\text{SF}_{\text{CTM}}) - \text{AMF}(\text{SF}_{\text{MAX-DOAS}}) / \text{AMF}(\text{SF}_{\text{MAX-DOAS}})$

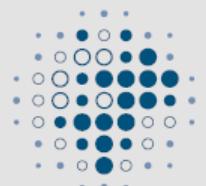


Difference of AMF increase along eCF ($\text{NO}_2 > \text{SO}_2$ and HCHO) \rightarrow BAMF effect

Compare original and improved VCD with MAX-DOAS



Under clear sky: including SF from MAX-DOAS improves the agreement (slope) of satellite VCDs with MAX-DOAS by 6% (NO_2), 35% (SO_2) and 17% (HCHO).



Conclusion:

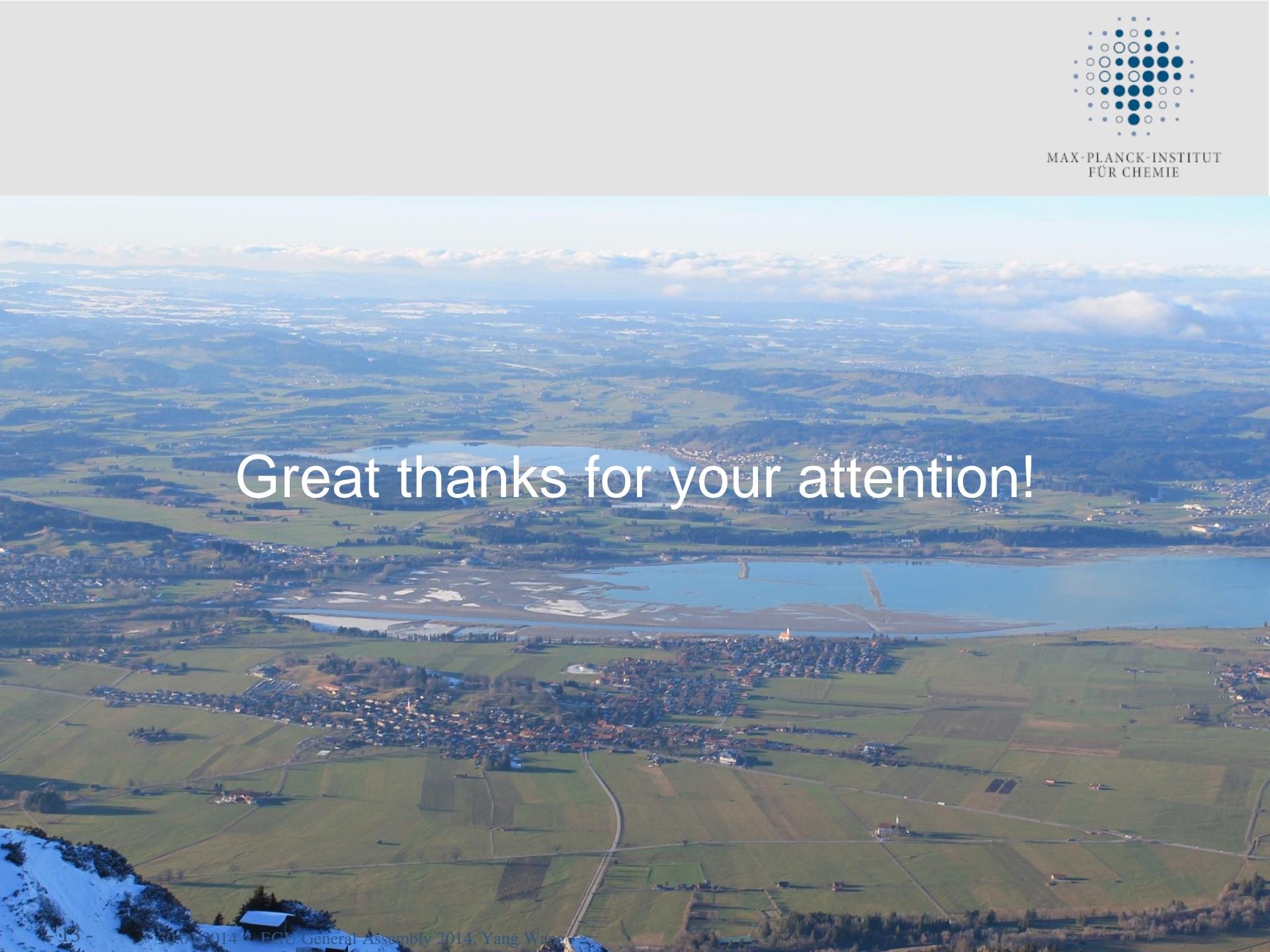
1. Coincident area of satellite products impact the validation activities much stronger than coincident time period of MAX-DOAS results. 20km is reasonably optimal selection for OMI. It is hard to determine for GOME-2.
2. Clouds cause large uncertainty and systematic bias of satellite VCDs; Clouds enlarge the effect of errors of CTM a-priori SF on VCDs.
3. Errors of CTM a-priori SF cause significant bias of SO₂ (~-30%) and HCHO (~-20%) VCDs, but negligible for NO₂ (under mostly clear sky condition).
4. Daily comparisons with MAX-DOAS: 1) NO₂: the best agreement for OMI DOMINO; GOME-2A/B are higher by ~30%; 2) SO₂: OMI BIRA has the best correlation, all products are lower by 50%; 3) HCHO: GOME-2B BIRA has the best correlation, all products are lower by ~15%.

Paper submitted to the OMI special issue of ACP, published soon ☺





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Great thanks for your attention!